

Original article

# Improvement in Cancer-Related Knowledge Following Use of a Psychoeducational Video Game for Adolescents and Young Adults with Cancer

Ivan L. Beale, M.Sc., Ph.D.<sup>a,\*</sup>, Pamela M. Kato, Ed.M., Ph.D.<sup>b,c</sup>,  
Veronica M. Marin-Bowling<sup>b</sup>, Nicole Guthrie, M.S.<sup>b</sup>, and Steve W. Cole, Ph.D.<sup>d</sup>

<sup>a</sup>*School of Psychology, University of New South Wales, New South Wales, Australia*

<sup>b</sup>*HopeLab, Palo Alto, California*

<sup>c</sup>*Department of Pediatrics, Stanford University, Stanford, California*

<sup>d</sup>*University of California–Los Angeles School of Medicine, Los Angeles, California*

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## Abstract

**Purpose:** Adolescents with chronic illnesses have been shown to have management and treatment issues resulting in poor outcomes. These issues may arise from non-interest in self care and illness knowledge. A video game, “Re-Mission,” was developed to actively involve young people with cancer in their own treatment. Re-Mission provides opportunities to learn about cancer and its treatment.

**Method:** The efficacy of Re-Mission was investigated in a multi-site, randomized, controlled study with 375 adolescent and young adult cancer patients. Participants received either a regular commercial game (control) or both the regular game plus Re-Mission (Re-Mission group). Participants were given a mini-PC with the games installed and requested to play for an hour each week for 3 months. A test on cancer-related knowledge was given prior to game play (baseline) and again after 1 and 3 months. At 3 months the Re-Mission group also rated the acceptability and credibility of Re-Mission.

**Results:** Analyses of the knowledge test scores showed that whereas scores of both groups improved significantly over the follow-up periods, the scores of the Re-Mission group improved significantly more. The size of this effect was related to usage of Re-Mission. Credibility scores were negatively correlated with level of knowledge but not with change in knowledge level at 1 month or 3 months.

**Conclusions:** The results indicate a specific effect of Re-Mission play on cancer knowledge that is not attributable to patients’ expectations. It is concluded that video games can be an effective vehicle for health education in adolescents and young adults with chronic illnesses. © 2007 Society for Adolescent Medicine. All rights reserved.

**Keywords:** Adolescents; Cancer; Video game; Knowledge; Psychoeducation

Survival statistics for young people with cancer have improved dramatically in recent decades [1], leading to new efforts to develop adjuvant interventions that will help patients to learn about and use effective self-care strategies

that will enhance recovery and quality of life [2,3]. Many psychoeducational interventions have been developed to change patients’ attitude to, and knowledge about, their treatment. However, analytic reviews of such interventions indicate that they vary widely in their effectiveness. In particular, there is little evidence that they are effective when used with adolescent and young adult patients [4,5]. It has been suggested that psychoeducational interventions

\*Address correspondence to: Ivan L. Beale, Ph.D., School of Psychology, University of New South Wales, Sydney, NSW, Australia.

E-mail address: [ibeale@psy.unsw.edu.au](mailto:ibeale@psy.unsw.edu.au)

might be more effective with adolescent and young adult patients if they made use of one of the video-game formats that are increasingly enjoyed by young people as a preferred recreational activity [5]. Video games have potential advantages as vehicles for learning, including high accessibility, ease of updating content, low cost per person served, high interactivity, high individualization of use, and the capability for attractive graphics, including animation and virtual reality [5].

The term “video game” is used in this report to refer to an electronic or computerized game played by manipulating images on a video display or television screen. It is a “game” in the sense that it may be played just for recreation, even where it may provide learning or instruction.

There are several reports of the use of video games as psychoeducational interventions for young people with chronic illnesses, although only one of these involved patients being treated for cancer. That study compared two small groups of children (4–11 years old) with leukemia who received either a video game intervention (Kidz with Leukemia) or an information booklet. Although the results showed some positive effects attributable to the game, there was no effect of the game or the booklet on knowledge about leukemia [6]. Comparable studies of children with other chronic diseases, such as asthma or diabetes, indicate that video games may be especially attractive to younger patients with chronic illnesses. However, it is equivocal whether these studies show that games can increase children’s knowledge about their illness and its treatment. In one study, asthmatic children 9–13 years old using a video game designed to facilitate pediatric asthma self-management were compared with a control group that received no intervention. The children receiving the game were subsequently found to have a higher level of knowledge about self-regulation, treatment and prevention, compared with the control group, even after adjustment for differences between the groups in pre-intervention knowledge levels [7]. The game seemed to be well-accepted as a fun activity, since 84% of the intervention group elected to continue using the game of their own volition after the study was completed.

Knowledge and skills relating to self-care among children with diabetes has also been targeted using a video game. In one study [8], children 8–16 years old receiving training with such a game were compared with a control group of children who had comparable use of a similar type of computer game with no diabetes-related content. Although there was evidence of some specific effects of the diabetes game on parent-reported self-care behaviors, there was no apparent effect on players’ knowledge.

The limited published research indicates that video games show some promise as a suitable vehicle for psychoeducational interventions designed to impart health knowledge to young patients with chronic illnesses. The studies indicate that games are an acceptable format for older chil-

dren and adolescents. It has been suggested that the efficacy of video games as a vehicle for imparting knowledge may be facilitated by the use of game designs that are based on sound learning principles [5,9]. This suggestion is supported by recent reviews of the theoretic bases of psychoeducation programs for children with chronic illnesses [10,11].

Re-Mission (HopeLab, Palo Alto, CA) is a video game designed to be played by young people undergoing treatment for cancer. The overall objective of the game is to change players’ illness representations in order to promote adherence to self-care during treatment and to teach self-care skills and related cancer knowledge. The theoretic basis for the expectation that the game will be an effective learning environment is a well-established extension of social learning theory known as “self modeling” [12]. The learning model used in Re-Mission is a novel, untested extension of the selective self modeling paradigm, for which the term “symbolic self modeling” has been suggested (Dowrick, personal communication, 2002).

The term “symbolic” refers to the fact that the model is not the learner *per se*, but an “avatar” (see below) that the learner controls during game play in a virtual environment. In the current literature on vicarious learning, learners observe either another person (in reality, on tape, or imagined) or themselves (on tape or imagined) achieving some performance goal. The observational context in Re-Mission differs from standard vicarious learning paradigms in that the player observes an agent who represents the player in the game (known in game parlance as an “avatar”) and whose behaviour the player controls. The player may learn from observing the consequences (desired and undesired) of the avatar’s actions, and may transfer what is learned to the player’s own behavior in the real world.

The game is designed to include procedural features that have been found, in other contexts, to maximize the likelihood that such transfer of learning will occur. The overarching procedural strategies relied on in Re-Mission for learning and transfer are based on those designated “feed-forward” and “positive self-review” in theoretical accounts of self modeling [12]. Feedforward occurs when the player views the virtual patient performing appropriate self-care behaviors (prompted by the avatar) and subsequently observes the desirable consequences of these behaviors. Positive self-review occurs when the player sees the avatar prompting the virtual patient to perform the appropriate self-care behavior.

The game genre in general has been seen as offering many features consistent with the concept of an efficacious learning environment. These include: self-selection of tasks from a menu of available activities; control and self-pacing of progress, with opportunities for exploration of the learning environment; and opportunities for incidental learning [13,14]. Additional strategies used in Re-Mission to promote learning of behavioral objectives include the use of prompts, selectable task difficulty, immediate feedback for

all alternative responses, unlimited opportunities for self-initiated practice and rehearsal, motivational relevance, and planned transfer of learning across situations and within response classes [9].

Re-Mission is a third-person action game in which the player can manipulate an avatar (a young humanoid robot character) on missions inside the three-dimensional (3-D) virtual bodies of 19 different young patients being treated for seven different cancers common in young people. The avatar is accompanied on these missions by a mentor robot who provides information, encouragement, warnings and prompts for appropriate actions. The game consists of two two-player missions and 20 single-player missions. Players win by destroying cancer cells and other enemies in the body (e.g., bacteria, mucositis lesions, stool jags), but they need to be careful not to waste ammunition or cause secondary damage to the body. Players destroy enemies by using weapons armed with common treatments such as chemotherapy, radiation, and antibiotics. To complete mission goals, the player must use game elements called “communication taps” to prompt the virtual patient to engage in positive self-care behaviors such as taking stool softeners to prevent colon tears, practicing good mouth care to combat mucositis, using relaxation techniques to reduce stress, communicating with the patients to take their medicine, or prompting the patient to eat and drink for more energy and to prevent dehydration. Re-Mission can be accessed at [www.re-mission.com](http://www.re-mission.com).

The game style, content and behavioral objectives are based on extensive research carried out with stakeholder groups in the U.S., including young people with cancer, oncologists and other physicians, psychologists and oncology nurses [4,5,15–17]. The selection of self-care behaviors targeted in Re-Mission was based primarily on a survey of pediatric oncology nurses’ judgments of relative importance of different behaviors [14].

Re-Mission was designed to be a learning environment that motivates, guides, and supports the learning of a set of behavioral objectives related to self care during treatment for cancer. To maximize its appeal to adolescent and young adult cancer patients, it has been given the look and feel of a high-quality commercial entertainment game, as opposed to an educational game. The learning curriculum and instructional components are present but integrated into the game-play agenda. Learning the underlying health-behavior objectives, although not essential to game play, enriches the game experience and facilitates achievement of mission objectives. The game provides opportunities to learn skills and knowledge content ranging from the very specific to more conceptual levels.

We have previously reported in a conference poster that patients given access to Re-Mission over a 3-month period showed more improvement on a range of measures of attitudes and behaviors than did a control group assigned to play a non-cancer game over the same period [18]. These

measures included quality of life, self-efficacy for self-care, and adherence to prescribed medication. Also it was reported that the Re-Mission group showed more improvement than the control group on a test of cancer knowledge. However, this basic finding is seen as subject to alternative interpretations, other than a specific effect of Re-Mission on knowledge. For example, the Re-Mission group might have performed better than the controls at follow-up because of higher motivation or confidence based on higher perceived efficacy (credibility) of their cancer-related intervention. The present paper reports further analyses of the nature of these knowledge gains, especially associations between knowledge gains, participants’ ratings of Re-Mission’s acceptability and credibility, and the extent to which participants used Re-Mission. The purpose of these analyses is to provide evidence for informed judgments about the specific effects of Re-Mission on cancer knowledge.

It was hypothesized that improvement in knowledge in the Re-Mission group would not be significantly associated with the valence of participants’ perceptions of the credibility of Re-Mission as an appropriate intervention. Also, it was hypothesized that in the Re-Mission group, the amount of improvement in knowledge would be positively associated with the amount that Re-Mission was actually played over the 3-month period.

## Methods

This report describes part of a larger randomized controlled evaluation of the efficacy of Re-Mission, relative to a control condition (a commercial videogame with no cancer content), as an intervention for several health related variables such as medication adherence, self care, and quality of life. Procedures and measures that were part of the larger study, but not relevant to the sub-study reported here, are not included in this report.

### *Statistical power and sample size*

Sample size was determined assuming a two-tailed statistical test to compare mean summary scores for a self-report measure of treatment adherence previously used in a pilot study. Assuming an  $\alpha = 0.05$  and power = 0.80 and based on pilot study results for the estimate of the variance in scores, a total sample size of 266 subjects would be required to detect a 0.20 unit difference in scores between the treatment group and the control group. The projected sample size was adjusted to take account of a 14% attrition rate estimated from the pilot study, yielding a minimum sample of 311.

### *Participants*

Approval to conduct the study was obtained from relevant research ethics authorities at 34 cancer treatment centers in the U.S., Canada, and Australia. Participants (N = 375) were recruited from those meeting the following in-

clusion criteria: male or female patient 13–29 years of age with a cancer diagnosis; must be currently receiving treatment and is expected to remain on treatment for at least 4–6 months. Exclusion criteria were: history of seizures caused by photosensitivity; unable to communicate effectively with study personnel in English, Spanish, or French; determined by the investigator to be incapable of following the study schedule or study directions for any reason. Of those recruited, 197 were randomly assigned to receive concurrent access to Re-Mission and an alternative non-cancer videogame, and 195 actually received the intervention. There were five participants whose assigned condition was crossed over ( $n = 3$  treatment to control,  $n = 2$  control to treatment) because of incorrect assignment to group by on-site study coordinators. 176 control patients received access only to the alternative non-cancer videogame. Of the 375 participants enrolled, the data from 4 were excluded from analyses because of inadequate consent ( $n = 2$ ), ineligibility ( $n = 1$ ), and consent withdrawal prior to any data collection ( $n = 1$ ).

### Procedures

Participants were asked to complete questionnaires on three occasions: at the commencement of the study (baseline); 1 month after baseline (follow-up [FU]); and 3 months after baseline (Long Term Follow-up; LTFU). The only questionnaires relevant to this sub-study were a brief demographic questionnaire given to all participants at baseline, a cancer knowledge test given to all participants on all three occasions, and a Re-Mission rating scale given at LTFU only to those assigned to receive Re-Mission. At baseline participants in the Re-Mission group were provided with a mini-PC loaded with two different videogames that could be played using game-pads provided. One game was Re-Mission, the other a regular commercial adventure game called Indiana Jones and The Emperor's Tomb (Lucas Arts, CA). In this game, players maneuver the main character through various obstacles in an action-adventure setting. Participants were told they could play both games. Participants in the control group were provided only with the Indiana Jones game. All participants were asked to play for at least an hour a week for the next 3 months. The mini-PC recorded durations of play for both games as well as tracking other specifics of Re-Mission play, including number of missions played and missions completed.

The cancer knowledge test was an 18-item test of knowledge about cancer and treatment that reflected basic information accessible to the player within Re-Mission (Table 1). The test items were chosen on the basis of consensus advice from pediatric oncology nurses. The test included multiple-choice questions regarding pediatric malignancies, their treatment, self-care strategies to minimize disease, and treatment-related complications that are addressed in Re-Mission. Because the questions were not measuring a single unidimensional construct, no reliabilities were computed.

Table 1

Items from Knowledge Test (upper panel) and Re-Mission Rating Scale (lower panel)

Knowledge Test	
1	Relaxation techniques can be used by patients with cancer to:
2	Hodgkin's disease usually starts in:
3	The best way to prevent infection is to:
4	Which of these helps prevent constipation?
5	Why is it important to take stool softener?
6	Experimental tumor vaccines attempt to:
7	A person with a low platelet count is most likely to get:
8	If patients with cancer forget to take a few doses of chemotherapy:
9	Which of the following is not a type of cancer?
10	After surgery for osteosarcoma, patients usually need:
11	Patients undergoing chemotherapy for cancer are susceptible to infection because of:
12	What can patients with cancer do to prevent mucositis?
13	Leukemia usually starts in:
14	What should patients with cancer do when they get fevers?
15	When a few cancer cells are still left inside the body after chemo treatment, they usually:
16	It takes at least how many cancer cells to regrow and cause a relapse?
17	A common location for osteosarcoma is the:
18	Which of these genes has been linked to some cases of a brain cancer?
Re-Mission Acceptability/Credibility Rating Scale	
1	I think it is OK for cancer patients to play Re-Mission.
2	I would recommend Re-Mission to another young person with cancer.
3	I think Re-Mission would help other people with cancer.
4	I think that playing Re-Mission would not be harmful to a patient.
5	I believe Re-Mission helped me understand cancer.
6	I believe I benefited from using Re-Mission.
7	Overall, I liked playing Re-Mission.
8	As a result of this game, I plan to make changes in how I manage my cancer treatment.
9	As a result of playing this game, I am more likely to take my medicine the way my doctor prescribed it.

Responses required to items were either yes/no or multiple choice. The Re-Mission rating scale was a nine-item rating scale designed to provide a measure of the participants' perceptions of the acceptability and credibility of Re-Mission as an intervention (Table 1). Participants were asked to respond to each item by reading the statement and then circling a rating value between 1 and 5 to indicate the extent to which they agreed (1 = strongly disagree, 5 = strongly agree). Credibility refers to perceived value of the videogame as an intervention capable of influencing knowledge, attitudes, or health outcomes. Acceptability refers to ease, enjoyment, and harmlessness of use. These constructs were chosen to reflect aspects of perception most applicable to the type of intervention being evaluated here: a videogame about cancer used by young patients being treated for cancer.

To assess acceptability and credibility in this specific study, a nine-item rating scale was constructed using items based on those used in scales validated in the literature on measurement of user's perceptions regarding concepts such as acceptability, credibility, and efficacy of interventions for behavioral management [19] or interventions widely used in

traditional and alternative medicine [20–22]. In the present study, acceptability is measured by four items reflecting the extent to which a patient would use the videogame as an enjoyable activity or recommend it, whereas credibility is measured by six items (1 item in common) reflecting the strength of the patient's belief that playing the videogame could influence a patient's knowledge, attitudes, or behavior relevant to treatment. For both subscales, internal consistency was found to be high (Chronbach's  $\alpha = .82$  [acceptability] and  $.91$  [credibility]). The knowledge test and the rating scale were scored by researchers blind to the research condition to which participants were assigned.

## Results

Of the 179 participants receiving the control condition, 169 completed the knowledge test at baseline, 149 at FU, and 141 at LTFU. Of the 196 participants given access to Re-Mission, 191 completed the knowledge test at baseline, 172 at FU, and 164 at LTFU; 148 filled out the acceptability/credibility rating scale at LTFU. The remaining 48 "non-completers" did not provide usable rating scale data at LTFU for the following reasons: completed study but did not complete the rating scale (16 patients); inadequate consent (one patient); early withdrawals (31 patients). Analyses of data on Re-Mission usage showed that completers played Re-Mission longer (mean 4.39, SD 5.16) than noncompleters (mean 1.21, SD 2.27) ( $t(192) = 4.05, p < .001$ ). Completers also played more unique game "missions" than noncompleters (completers, mean 5.20, SD 6.18; noncompleters, mean 2.28, SD 4.09;  $t(192) = 3.00, p < .01$ ). Completers and noncompleters did not differ significantly in age, gender, prior video game use, or the amount of time spent playing Indiana Jones. There was no significant difference between completers and noncompleters in, educational level, the median educational level of both completers and noncompleters being grades 9 and 10.

Table 2  
Characteristics of participants at Baseline

Variable	Group	N	Mean	SD	<i>p</i>
Baseline Knowledge Score	Control	169	59.73	15.61	>.05 <sup>a</sup>
	Re-Mission	191	59.31	16.90	
Prior game experience (hours per week)	Control	166	3.09	1.26	>.05 <sup>a</sup>
	Re-Mission	190	3.04	1.27	
Age	Control	176	16.06	2.89	>.05 <sup>a</sup>
	Re-Mission	195	15.79	2.62	
Male gender	Control	119			>.05 <sup>b</sup>
	Re-Mission	132			
Female gender	Control	57			>.05 <sup>b</sup>
	Re-Mission	63			

<sup>a</sup> *t*-Test, Re-Mission vs. control.

<sup>b</sup>  $\chi^2$  test, Re-Mission vs. control.

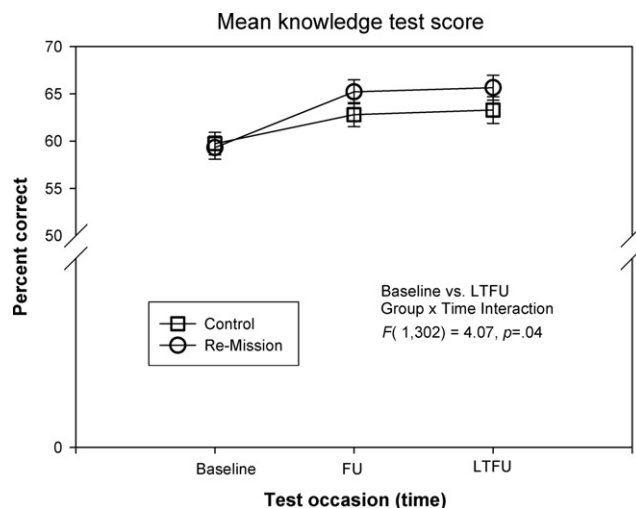


Figure 1. Mean knowledge test score and standard error are shown for each group (Control, Re-Mission) for each test occasion (baseline, Follow-up (FU), Long-term Follow-up (LTFU)).

### Group comparisons at baseline

Diagnoses were as follows: leukemia 49%, lymphoma 17%, and solid tumor 34%. Participants' characteristics for both groups are shown in Table 2. Differences between Re-Mission and control group means were tested for continuous variables using *t*-tests, and found not significant ( $p > .05$ ) for age, amount of prior video-game experience, or knowledge test scores at baseline. A  $\chi^2$  test showed that the proportion of males and females was not significantly different ( $p > .05$ ) between the two groups.

### Changes in knowledge test scores over time

Group means for knowledge test scores are shown for all three testing occasions (Figure 1). Figure 1 indicates that mean scores of both groups increased both between baseline and FU and between FU and LTFU. It also appears that the amount of increase is larger for the Re-Mission group than for the control group. This observation is supported by a repeated-measures analysis of variance conducted with one within-subjects factor (Time: baseline, LTFU) and one between-subjects factor (Group: control, Re-Mission). Significant effects were the main effect of Time ( $F(1,302) = 43.7, p < .001, f = .126$ ) and the Group  $\times$  Time interaction ( $F(1,302) = 4.07, p = .04, f = .013$ ).

A multiple regression analysis was conducted to check whether amount of change in knowledge scores between baseline and LTFU was predictable from age, gender, or amount of previous video game experience. The linear model was not significant ( $p > .05$ ).

A discriminant function analysis was performed to identify specific test items on which knowledge gains best predicted group allocation. The purpose was to see whether the best predictors involved item content featured in missions occurring early in Re-Mission play and therefore experi-

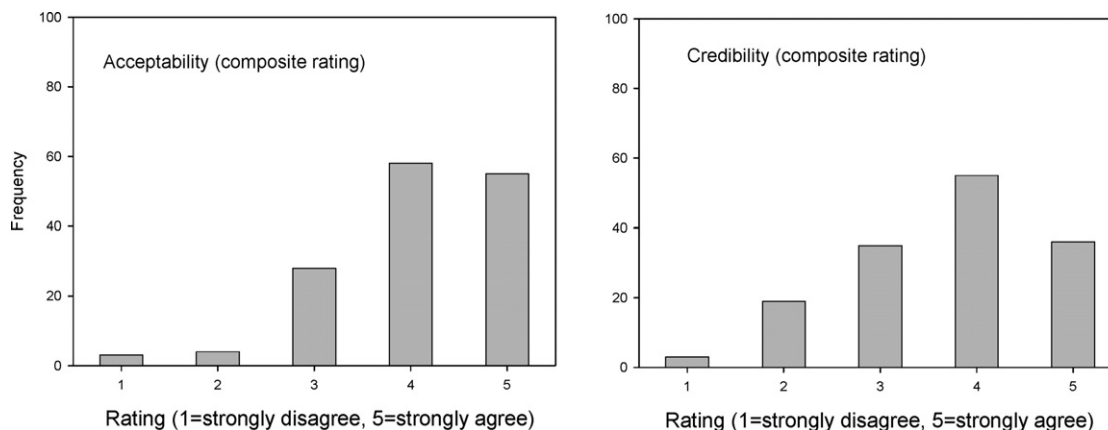


Figure 2. The distributions of composite ratings of acceptability (left) and credibility (right) are shown for the Re-Mission group.

enced by most Re-Mission participants. Only one item (Item 15) had useful discriminant validity, correctly classifying 58% of participants ( $F(1,247) = 9.63, p = .002$ ). This item (Table 1) features in two of the first three missions encountered by Re-Mission players.

#### Factors associated with knowledge growth in the Re-Mission group

A multiple regression analysis was conducted to ascertain whether amount of change in knowledge scores in the Re-Mission group between baseline and LTFU was predictable from age, gender, hours of Re-Mission play, number of different missions played, or amount of previous video game experience. The linear model was not significant ( $p > .05$ ).

Scores on items of the Re-Mission rating scale were combined to yield composite scores for acceptability (Items 1, 2, 4, and 7) and credibility (Items 2, 3, 5, 6, 8, and 9). Distributions of these composite ratings (Figure 2) show that most participants in the Re-Mission group perceived Re-Mission as acceptable and credible as an intervention, composite ratings in categories 4 and 5 being more frequent than ratings in the categories 1–3.

Calculations of correlation coefficients showed that neither composite score (acceptability or credibility) was significantly associated with amount of increase in knowledge scores between baseline and LTFU. However, composite credibility score was significantly negatively associated with absolute knowledge scores at FU ( $r(142) = -.20, p = .016$ ). Further exploration of correlations between knowledge scores and individual rating scale items showed only two significant associations. Ratings on Items 8 and 9 both were significantly negatively correlated with knowledge scores at baseline, FU and LTFU ( $r$  values range from  $-.19$  to  $-.32, p < .01$ ).

#### Re-Mission access versus Re-Mission play

Play records kept by the mini-PCs used for game play showed that most of the Re-Mission group played Re-

Mission for only a short time, although a small number played the game extensively (Figure 3). The mean playing time was 3.63 hours (median 1.82), and the mean number of unique missions played was 4.5 (median 2). Of the 194 participants who received access to Re-Mission, 32 did not play Re-Mission at all. In the analyses previously described, the Re-Mission group includes both the non-players and the players. However, it may be of interest to see whether there is much change in results when non-players are excluded from the Re-Mission group in analyses. When these exploratory analyses were conducted, the changes in results were relatively minor, although all involved larger differences between performances of the Re-Mission and control groups, compared with the primary analyses of the groups with all participants included. For example, the repeated-measures analysis of variance yielded larger  $F$  values and effect sizes (calculated as partial eta-squared ( $f$ ) for both significant effects (Time:  $F = 48.1, p = .0001, f = .14$ ; Time  $\times$  Group:  $F = 5.33, p = .02, f = .018$ ).

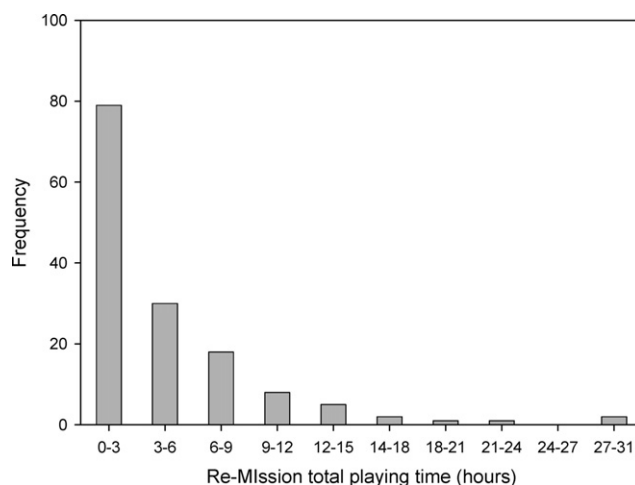


Figure 3. The distribution of total Re-Mission playing times is shown for participants assigned to play Re-Mission.

## Discussion

The control and Re-Mission groups were found to be equivalent on variables that might be considered relevant to how they would respond to the interventions they received. In any case, none of these variables (age, gender balance, prior video game experience, and baseline knowledge test score) were found to be significantly associated with amount of improvement of knowledge following intervention.

Although both groups showed significant increases in knowledge scores over the three months of the intervention, significantly larger increase was evident for the group receiving Re-Mission, as compared with the group receiving the control game. Why should knowledge increase in the control group when the intervention they received was without cancer knowledge content? Presumably, because, in addition to any knowledge received specifically through the video game intervention, patients received relevant information about their illness and its treatment through the health professionals and agencies responsible for their treatment. This would be expected to occur prior to, during and after the intervention. Patients' uptake and understanding of information provided to them, including instructions about self care, is thought to vary according to variables such as their preparedness to receive information and their motivation to understand it [17]. The larger relative gain in knowledge by the Re-Mission group could reflect both exposure to information included in Re-Mission and greater interest, stimulated by Re-Mission, to seek information elsewhere (from health professionals, the Internet, etc). It is relevant to this issue that most participants in the Re-Mission group did not play Re-Mission extensively, the median number of the 20 available missions played being only two (mean, 4.5). This means that many of the Re-Mission group would not have accessed much of the information spread across the 20 missions, and this would severely limit the impact of this information content on knowledge test scores. This might seem to favor the interpretation that playing Re-Mission results in increased knowledge scores, relative to the control intervention, primarily because it stimulates interest in understanding illness issues. On the other hand, it is notable that the single knowledge test item that significantly differentiates between knowledge gains by the control versus Re-Mission groups is an item related to information content contained in the first few missions encountered by Re-Mission players.

The role of actual Re-Mission play as an agent in increasing knowledge is brought into question by the finding that the magnitude of knowledge gains following intervention is not associated either with recorded hours of Re-Mission play, or with the number of unique missions completed. On the other hand, there is the finding that larger effects favoring Re-Mission were obtained from analyses that excluded non-players from the Re-Mission group.

Before attempting to reconcile these apparently disparate findings, it might be useful first to turn to the evidence about the associations between knowledge scores and the Re-Mission participants' ratings of acceptability and credibility of Re-Mission as an intervention. Gains in knowledge following intervention were not significantly associated with participants' perceptions of the acceptability or credibility of Re-Mission. This finding shows that the demonstrated superiority of Re-Mission as an agent for knowledge gain is not somehow related to positive perceptions of the game as a pleasant activity or therapeutic intervention. The significant negative correlation between absolute knowledge scores and composite credibility ratings, and especially ratings on Items 8 and 9, is a clear indication that more-knowledgeable participants tend to be skeptical of the ability of the game to bring about changes in their self-care behaviors. These findings appear to be inconsistent with an interpretation that the Re-Mission participants do better than the controls simply because of their higher expectations.

It is concluded that having access to Re-Mission over a 3-month period resulted in knowledge gains significantly exceeding those produced by having access only to a control game without cancer content. The superior effect of access to Re-Mission was enhanced when Re-Mission was actually played at some time during the period of access. Knowledge gains were not attributable to players' perceptions about the acceptability of the game, or their expectations about the credibility of the game as an intervention. It must be acknowledged that the size of the treatment effect on knowledge was small, even though the effect was statistically significant. An effect of this size would not of itself recommend the allocation of the significant resources required for the development of video games to improve cancer treatment outcomes. However, it may be valuable to potential health game developers to see the evidence reported here supporting a causal relation between game play and knowledge gains consistent with the strategies used in the game design.

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